N87-10304

LASER SOUNDING OF INSTANTANEOUS AND MEAN SPEED OF WIND USING CORRELATION METHOD

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The correlation methods for laser sounding of wind speed are based on mutual processing of lidar signals scattered from several spatially separated volumes at each altitude investigated. The time of atmospheric aerosol transport between the scattering volumes estimated by the position of maximum of the mutual correlation function is the measure of corresponding wind speed. In this case the distance between the scattering volumes (the measuring base), defining the time of aerosol movement through the measuring base also determines the lidar possibilities for measuring the instantaneous (during the time interval of several seconds) or the mean wind speed (some minutes). In this paper, based on the experimental investigations carried out using two lidars, these possibilities have been analyzed.

In the temporal correlation method the information on wind speed is extracted from temporal realizations of lidar signals whose total duration is the time interval of averaging the measured wind speed. Taking into account the requirements on completeness of statistics, the duration of realizations T can be connected with the geometric lidar parameters and the least measured wind speed V_M by the relation [1]

$$T = 10\xi_0 / V_M$$

where ξ_0 is the measuring base. If 1 m/s is taken as a threshold value of the measured speed, one can determine the value of the measuring base for the laser meter of instantaneous and mean wind speed. The measuring base should be about 0.5 m and 30 m, respectively.

Two lidars have been constructed which have sufficiently different measuring bases. The geometric scheme of lidar for measuring the instantaneous wind speed is given in Fig.1. The laser 1 generated the light pulses at the 0.53 μm wavelength, 4 mrad divergence and 50 Hz pulse repetition rate. The radiation reflected by the atmosphere was collected with the objective 2 of 100 mm diameter and 1 m focal length. In the focal plane of the objective there was a mirror prism 3, which divided the image of scattering volumes into two parts (the shapes of the divided flows are shown in the top of the figure) and directed the light flows to the photomultipliers 4. The prism position corresponded to the measurement of the horizontal transverse speed of wind. The distance between the scattering volumes, as a measuring base [1] depended on the range L and was $\xi_0 = 0.002 \cdot L$.

An example of measuring the transverse wind speed at sounding at an elevation angle of 20° is given in Figure 2, where the mutual-correlation funotions at different ranges are shown. The values of transverse speed V_1 were determined from the expression $V_1 = 0.002 L / \tau'$, where τ' is the position of maximum of mutual-correlation function. The duration of temporal realizations was 5 s. The time of measurement can be further decreased if one increases the pulse repetition rate and decreases the divergence of laser pulses.

The lidar for measuring the mean speed had three sounding paths forming, at each altitude, the scattering volumes located at the vertices of a right-angled isosceles triangle, one of the cathetus of which coincides with direction to the north. The pulse repetition rate was 3.3 Hz. Figure 3 illustrates the mutual-correlation functions of signals at the 1 km altitude at wind speed 16.5 m/s and direction 153° (the point 2 is at the right-angle vertex). The distance between the scattering volumes at this altitude was 150 and 105 m, respectively. The correlation functions have maxima displaced from the origin of coordinates, which allow one to estimate the modulus and direction of wind using the method of complete correlation analysis [1]. The time of measuring the mean wind speed was 5...10 min.

Figure 4 gives the comparison of profiles of the mean wind speed modulus measured using lidar 1 and theodolite 2. As seen from Fig.4, the difference does not exceed 1 m/s.

The paper also presents the comparison with the aerological data on wind speed.

References

1. Correlation methods of laser-sounding measurements of wind speed / Matvienko G.G., Zadde G.O., Ferdinandov E.S. et al. Novosibirsk, Nauka, 1985.

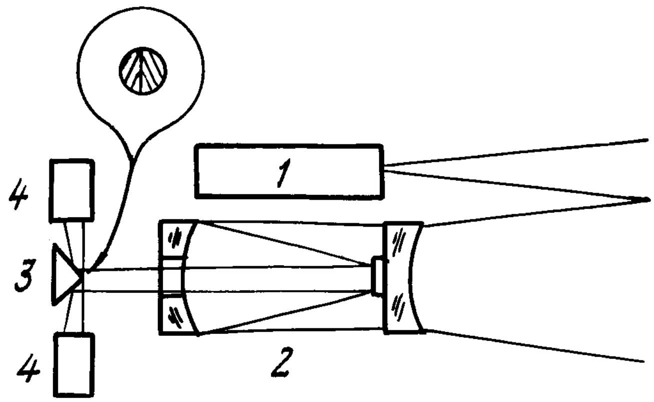

4
1
3
4
2

Fig. 1

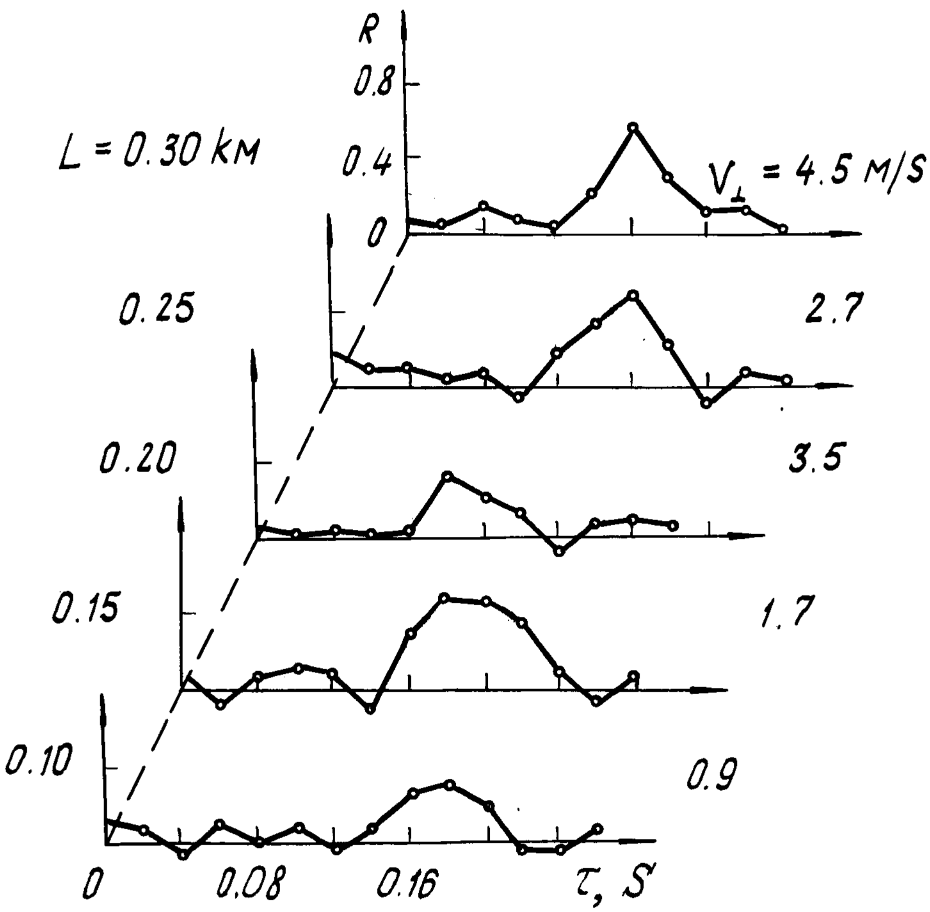
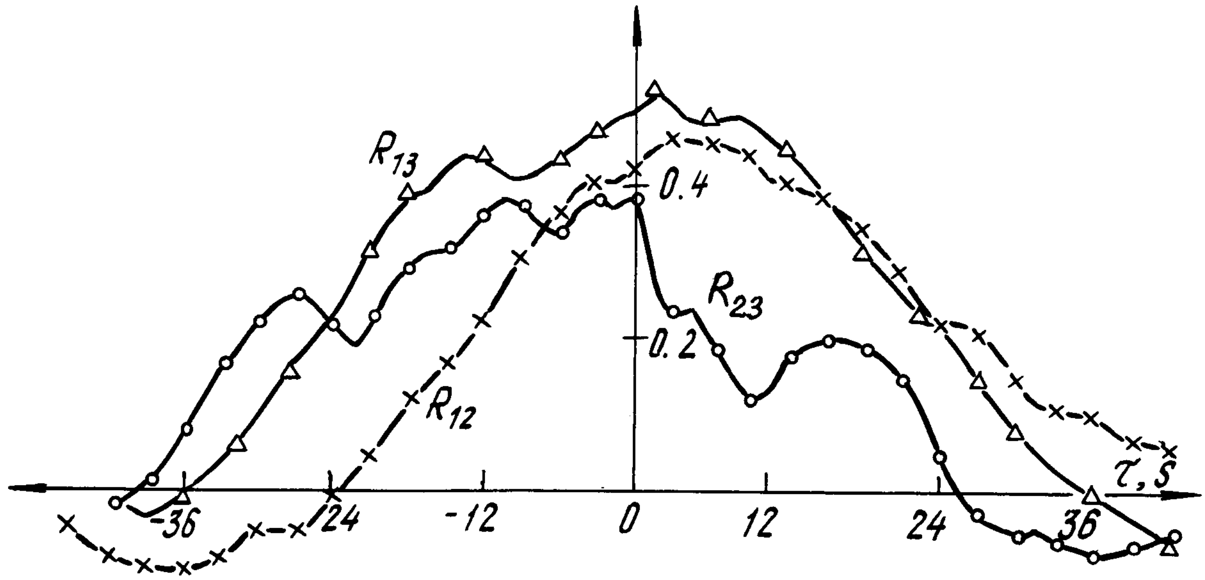
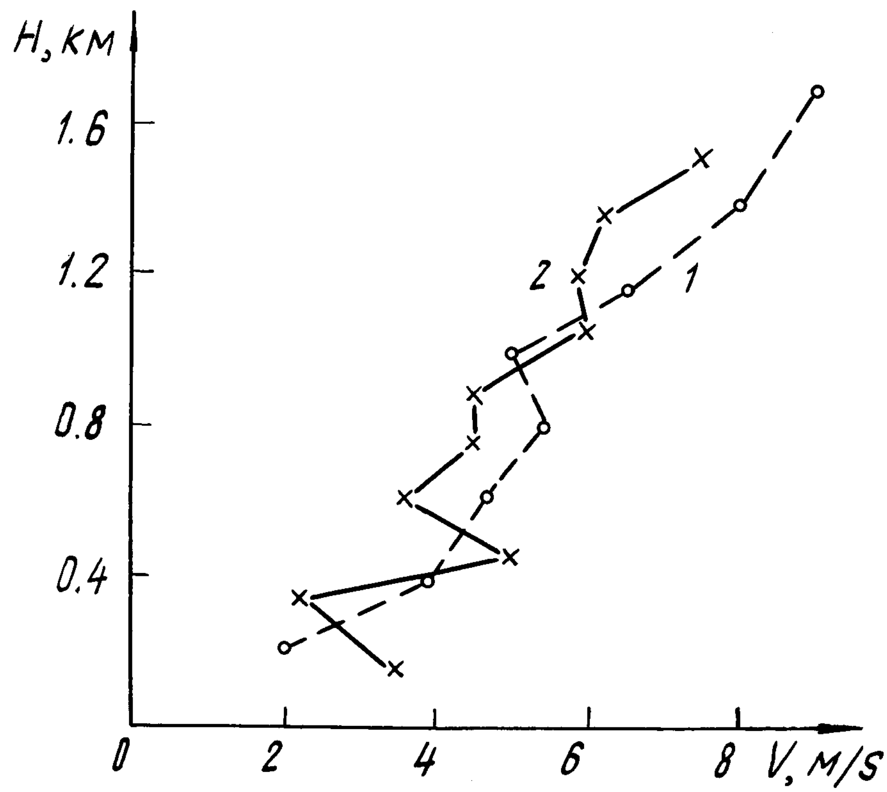

R
0.8
0.4
0
L = 0.30 km
$V_{\perp}$ = 4.5 m/s
0.25
2.7
0.20
3.5
0.15
1.7
0.10
0.9
0
0.08
0.16
τ, s

Fig. 2



R_{13}
R_{23}
R_{12}
0.4
0.2
-36
-24
-12
0
12
24
36
τ, S

Fig. 3



H, KM
1.6
1.2
0.8
0.4
0
2
4
6
8
V, M/S
2
1

Fig. 4